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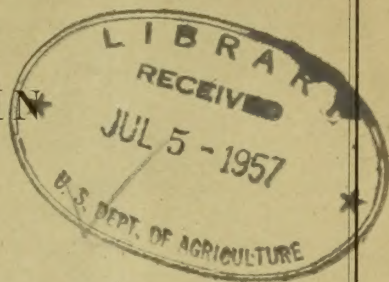
U. S. GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES.

F. V. HAYDEN, U. S. GEOLOGIST-IN-CHARGE.

BULLETIN

OF

THE UNITED STATES



ENTOMOLOGICAL COMMISSION.

ON THE NATURAL HISTORY OF THE ROCKY MOUNTAIN LOCUST,
AND ON THE HABITS OF THE YOUNG OR UNFLEDGED INSECTS
AS THEY OCCUR IN THE MORE FERTILE COUNTRY IN
WHICH THEY WILL HATCH THE PRESENT YEAR.

No. 2.

SECOND EDITION.

WASHINGTON:
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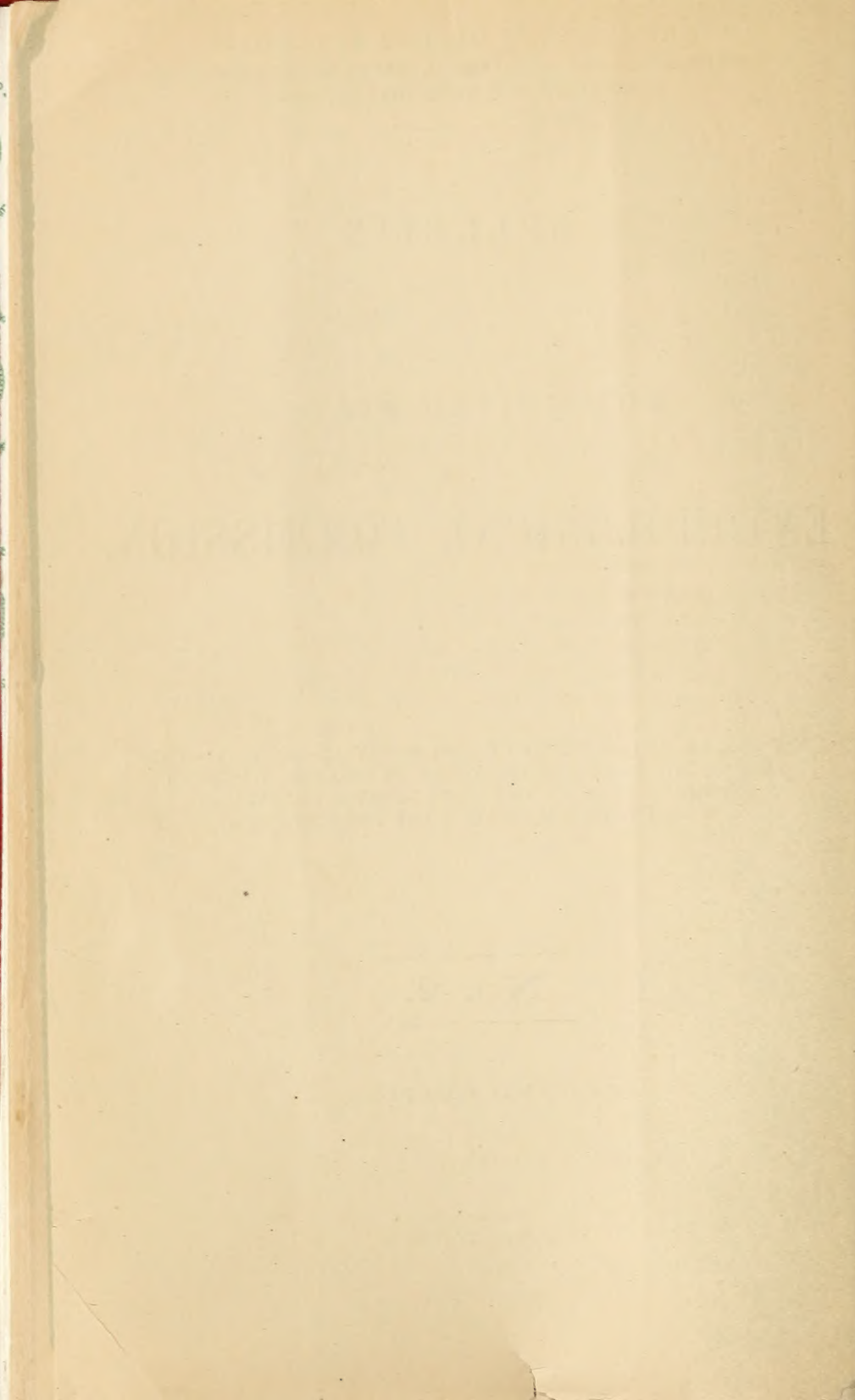
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PREFACE.

The present Bulletin has been prepared in accordance with the purpose of the Commission to issue Bulletins containing special information that is of interest and sought for at the time of publication. In preparing this Bulletin, No. 2, we have made large use of Professor Riley's Entomological Reports to the State of Missouri, and this the more readily that they are in limited circulation outside of that State, and because the legislature has made no provision for the distribution of the last.

The map at the end will illustrate in a general way the country that will most severely suffer, and the eastern limit of injury the present year.

C. V. RILEY,
A. S. PACKARD, JR.,
CYRUS THOMAS,
Commissioners.

ON THE NATURAL HISTORY OF THE ROCKY MOUNTAIN LOCUST, AND ON THE HABITS OF THE YOUNG OR UNFLEDGED INSECTS AS THEY OCCUR IN THE MORE FERTILE COUNTRY IN WHICH THEY WILL HATCH THE PRESENT YEAR.

CHARACTERS OF THE SPECIES.

Though often confounded with other species, the Rocky Mountain Locust may be recognized by the following characters: It measures on an average about $1\frac{1}{2}$ inches from the head to the tip of the closed wings, and the wings extend about one-third their length beyond the tip of the abdomen. The color is variable, but the more common specimens are yellowish-white beneath; glaucous or cabbage-blue across the breast

Fig. 1.



ROCKY MOUNTAIN LOCUST.

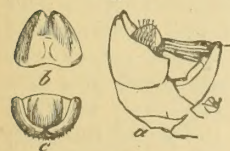
Fig. 2.



RED-LEGGED LOCUST.

and about the mouth parts; pale-bluish, often with shades of purple, on the sides of the head and thorax and on the front of the face; olive-brown on the top of the head and thorax; pale beneath, more or less bluish above and marked with black, especially toward the base, on the abdomen. The front wings have the ground-color pale grayish-yellow, inclining to green, and their spots and veins brown; the hind wings, except a yellowish or brownish shade at apex and along the front edge and a green tint at base, are transparent and colorless, with the veins brown. The front and middle legs are yellowish. The hind legs have the thighs striped with pale glaucous and reddish on the outside and upper half of inside, with four broad black or dusky marks on the upper edge, the terminal one extending beneath around the knee. The shanks are coral-red, with black spines; the feet somewhat paler, with black claws; antennæ pale yellow; palpi tipped with black. In the dead specimens all these colors become more dingy and yellow. It very

Fig. 3.

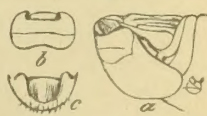


ROCKY MOUNTAIN LOCUST.—Anal characters of male: a, side view; b, c, hind and top views, of tip.

less conspicuously spotted wings (seldom extending more than one-sixth of their length beyond the tip of the abdomen), and the last abdominal joint of the male (Fig. 4) is bluntly cut off at the top, and not tapering and notched as in the *C. spretus* (Fig. 3).

closely resembles, and is often confounded with the Red-legged Locust (*Caloptenus femur-rubrum*, De Geer), a species common to the whole middle portion of the continent from the Atlantic to the Rocky Mountains, which, though capable of short flights, never commit the same havoc. This last

Fig. 4.



RED-LEGGED LOCUST.—Anal characters of male: a, side view; b, c, hind and top views, of tip.

THE EGGS.

The question as to how best to treat the soil or to manage the eggs so as to most easily destroy their vitality is a most important and practical one. Everything, therefore, that relates to the eggs—the manner of deposition, the character of the mass, the method of hatching, &c., even to the minutest details—becomes important and is worthy of careful study.

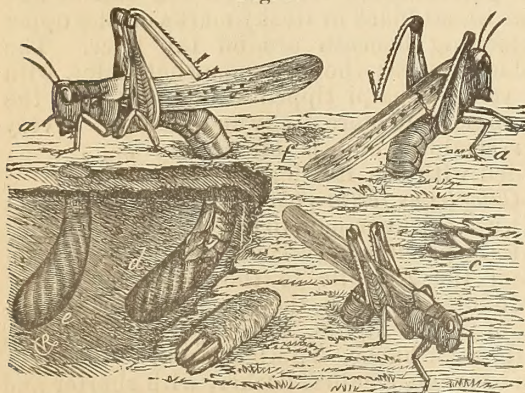
WHERE THE EGGS ARE LAID.

The eggs may be laid in almost any kind of soil, but by preference they are laid in bare, sandy places, especially on high, dry ground, which is tolerably compact and not loose. It is generally stated that they are not laid in meadows and pastures, and that hard road-tracks are preferred; in truth, however, meadows and pastures, where the grass is closely grazed, are much used for ovipositing by the female, while on well-traveled roads she seldom gets time to fulfill the act without being disturbed. Thus a well-traveled road may present the appearance of being perfectly honey-combed with holes, when an examination will show that most of them are unfinished, and contain no eggs; whereas a field covered with grass-stubble may show no signs of such holes and yet abound with eggs. Furthermore, the insects are more readily noticed at their work along roads and roadsides than in fields, a fact which has also had something to do in forming the popular impression. Newly broken or ploughed land is not liked; it presents too loose a surface. Moist or wet ground is generally avoided for the purpose under consideration. During the operation the female is very intent on her work and may be gently approached without becoming alarmed, though when suddenly disturbed she makes great efforts to get away and extricates her abdomen in the course of a few seconds, the time depending on the depth reached.

HOW THE EGGS ARE LAID.

The female, when about to lay her eggs, forces a hole in the ground by means of the two pairs of horny valves which open and shut at the tip of her abdomen, and which, from their peculiar structure, are admirably fitted for the purpose.

Fig. 5.



ROCKY MOUNTAIN LOCUST.—*a, a, a*, female in different positions, ovipositing; *b*, egg-pod extracted from ground, with the end broken open; *c*, a few eggs lying loose on the ground; *d, e*, show the earth partially removed, to illustrate an egg-mass already in place, and one being placed; *f*, shows where such a mass has been covered up.

(See Fig. 6, where *b, c* show the structure of one of each of the upper and lower valves). With the valves closed she pushes the tips in the ground, and by a series of muscular efforts and the continued opening and shutting of the valves, she drills a hole until in a few minutes (the time varying with the nature of the soil) nearly the whole abdomen is buried. The abdomen stretches to its utmost for this purpose, especially at the middle, and the hole is generally a little curved, and always more or less ob-

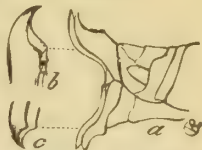
lique (Fig. 5, *d*). Now with hind legs hoisted straight above the back, and the shanks hugging more or less closely the thigh, she commences ovipositing. If we could manage to watch a female during the arduous work of ovipositing we should find that, when the hole is once drilled, there commences to exude at the dorsal end of the abdomen, from a pair of sponge-like exsertile organs (Fig. 7, *h*) that are normally retracted and hidden beneath the super-anal plate (Fig. 7, *i*), near the cerci, a frothy, mucous matter which fills up the bottom of the hole. Then with two pairs of valves brought close together, an egg would be seen to slide down the oviduct (*j*) along the ventral end of the abdomen, and, guided by a little finger-like style,* (*g*) pass in between the horny valves (which are admirably constructed not only for drilling, but for holding and conducting the egg to its appropriate place) and issue at their tips amid the mucous fluid already spoken of. Then follows a period of convulsions, during which more mucous material is elaborated, until the whole end of the body is bathed in it, when another egg passes down and is placed in position. These alternate processes continue until the full complement of eggs are in place, the number ranging from 20 to 35, but averaging about 28. The mucous matter binds all the eggs in a mass, and when the last is laid the mother devotes some time to filling up the somewhat narrower neck of the burrow with a compact and cellulose mass of the same material, which, though light and easily penetrated, is more or less impervious to water, and forms a very excellent protection (Fig. 8, *d*).

PHILOSOPHY OF THE EGG-MASS.

To the casual observer the eggs of our locust appear to be thrust indiscriminately in the hole made for their reception. A more careful study of the egg-mass or egg-pod will show, however, that the female took great pains to arrange them, not only so as to economize as much space as possible consistent with the form of each egg, but so as to best facilitate the escape of the young locust; for if any of the bottom eggs were to hatch before the upper or anterior ones, their issue would, in their efforts to escape, disturb and injure the other eggs, were there no

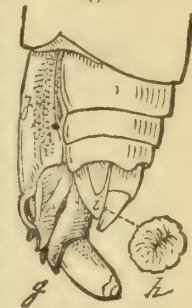
provision against such a possibility. The eggs are, indeed, most carefully placed side by side in four rows, each row generally containing seven. They oblique a little crosswise of the cylinder (Fig. 8, *a*). The posterior or narrow end, which issues first from the oviduct, is thickened, and generally shows two pale rings around the darker tip (Fig. 9, *a*). This is pushed close against the bottom of the burrow, which, being cylindrical, does not permit the outer or two side rows to be pushed quite so far down as the two inner rows,

Fig. 6.



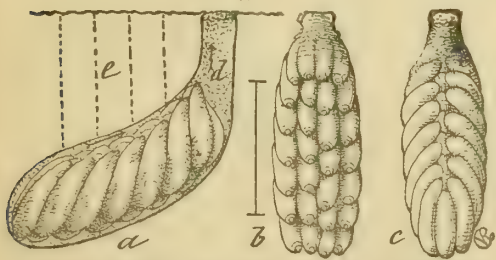
ROCKY MOUNTAIN LOCUST.—Anal characters of female, showing horny valves.

Fig. 7.



OVIPOSITION OF ROCKY MOUNTAIN LOCUST.

Fig. 8.



EGG-MASS OF ROCKY MOUNTAIN LOCUST.—*a*, from the side, within burrow; *b*, from beneath; *c*, from above—enlarged.

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* This is a simple process or extension of the sternite, and may be known as the egg-guide, or *gubernaculum ovi*.

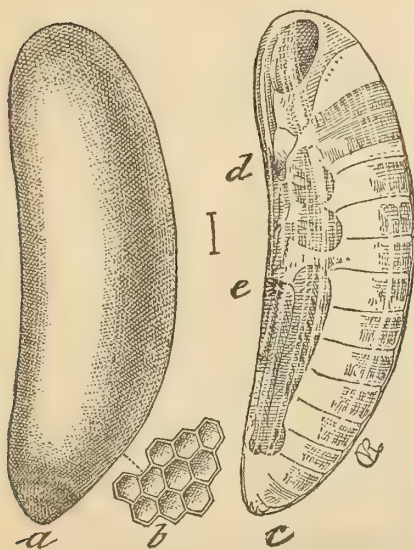
and for the very same reason the upper or head ends of the outer rows are necessarily bent to the same extent over the inner rows, the eggs when laid being somewhat soft and plastic. There is, consequently, an irregular channel along the top of the mass (Fig. 8, *c*), which is filled only with the same frothy matter which surrounds each egg and occupies all the other space in the burrow not occupied by the eggs. The whole plan is seen at once by a reference to the accompanying figure, which represents, enlarged, a side view of the mass within the burrow (*a*), and a bottom (*b*) and top (*c*) view of the same with the earth which adheres to it removed.

HOW THE YOUNG LOCUST ESCAPES FROM THE EGG.

Carefully examined, the egg-shell is found to consist of two layers. The outer layer, which is thin, semi-opaque, and gives the pale cream-yellow color, is seen by aid of a high magnifying power to be densely, minutely, and shallowly pitted, or, to use still more exact language, the whole surface is netted with minute and more or less irregular hexagonal ridges (Fig. 9, *a*, *b*). The inner layer (the chorion) is thicker, of a deeper yellow, and perfectly smooth. It is also translucent, so that, as the hatching period approaches, the form and members of the embryo may be distinctly discerned through it. The outer covering is easily ruptured, and is rendered all the more fragile by freezing; but the inner covering is so tough, that a very strong pressure between one's thumb and finger is required to burst it. How, then, will the embryo, which fills it so compactly that there is scarcely room for motion, succeed in escaping from such a prison? The rigid shell of the bird's egg is easily cracked by the beak of its tenant; the hatching caterpillar, curled within its egg-shell, has room enough to move its jaws and eat its way out; the egg-coverings of many insects are so delicate and frail, that

the mere swelling of the embryo affords means of escape; those of others so constructed that a door flies open or a lid lifts by a spring whenever pressure is brought to bear; in some, two halves open, as in the shell of a muscle; while in a host of others the embryo is furnished with a special structure called the egg-burster or egg-tooth (*ruptor ovi*), the office of which is to cut or rupture the shell, and thus afford means of escape. But our young locust is deprived of all such contrivances. Nature accomplishes the same end in many different ways. She is rich in devices. The egg increases considerably in size before hatching, and the shell necessarily becomes weaker as it stretches. At last, by the muscular efforts of the nascent locust and the swelling of its several parts, especially about the head and mouth, the shell gives way, generally splitting along the anterior ventral part. All the eggs in a given mass burst very much at one

Fig. 9.



EGG OF ROCKY MOUNTAIN LOCUST.—*a*, showing sculpture of outer shell; *b*, the same very highly magnified; *c*, the inner shell just before hatching; *d*, *e*, points where it ruptures.

and the same time, and in that event the lowermost individuals await the escape of those in front of them, which first push their way out through the neck of the burrow (Fig. 8, *d*) provided by the parent. They all escape one after the other through one small hole, which is scarcely noticeable in the field.

Such is the usual mode of hatching; but when the young from the lower eggs hatch first, or when the upper eggs perish and leave the lower ones sound, as is not unfrequently the case, the exit is nevertheless easily made along the channel already described (Fig. 8, *c*).

By a series of undulating movements the nascent larva soon works itself entirely out of the egg, when it easily makes its way along the channel already described, without in the least interfering with the other eggs, and finally forces a passage-way up through the mucous filling in the neck of the burrow (Fig. 8, *d*). Once fully escaped from the soil, it rests from its exertions, but for a short time only. Its task is by no means complete; before it can feed or move with alacrity it must molt a pellicle* which completely incases every part of the body. This it does in the course of three or four minutes, or even less, by a continuance of the same contracting and expanding movements which freed it from the earth, and which now burst the skin on the back of the head. The body is then gradually worked from its delicate covering until the last of the hind legs is free, and the exuvium remains, generally near the point where the animal issued from the ground, as a little, white, crumpled pellet. Pale and colorless at first, the full-born insect assumes its dark-gray coloring in the course of half an hour.

From this account of the hatching process, we can readily understand why the female in ovipositing prefers compact or hard soil to that which is loose. The harder and less yielding the walls of the burrow, the easier will the young locust crowd its way out.

The covering which envelops the little animal when first it issues from the egg, though quite delicate, undoubtedly affords protection in the struggles of birth from the burrow, and it is an interesting fact that while it is shed within a few minutes of the time when the animal reaches the free air, it is seldom shed if, from one cause or other, there is failure to escape from the soil, though the young locust may be struggling for days to effect an escape.

While yet enveloped in this pellicle, the animal possesses great forcing and pushing power, and if the soil be not too compact, will frequently force a direct passage through the same to the surface, as indicated at the dotted lines, Fig. 8, *e*. But it can make little or no headway, except through the appropriate channel (*d*), where the soil is at all compressed. While crowding its way out, the antennæ and four front legs are held in much the same position as within the egg, the hind legs being generally stretched. But the members bend in every conceivable way, and where several are endeavoring to work through any particular passage, the amount of squeezing and crowding they will endure is something remarkable. Yet if by chance the protecting pellicle is worked off before issuing from the ground, the animal loses all power of further forcing its way out. The instinctive tendency to push upward is also remarkable. In glass tubes, in which the eggs have been placed in order to watch the method of hatching, the young always turned their heads and pushed toward the bottom whenever the tubes were turned mouth downward; while in tin boxes, where the eggs were placed at different depths in the ground, the young never descended, even when

* This pellicle (the *amnion*) is common to most insects, but so far as we have observed it is shed after leaving the chorion principally by the orthoptera and neuroptera.

they were unable to ascend on account of the compactness of the soil above.

TIME OF HATCHING.

The date at which the eggs hatch varies with the earliness or lateness of the spring, and is moreover quite irregular, some hatching in the same locality when the first-hatched locusts are getting wings. As a general rule, however, the bulk of the eggs hatch out in the different latitudes about as follows:

In Texas, from the middle to last of March.

In the southern portion of Missouri and Kansas, about the second week in April.

In northern parts of Missouri and Kansas and southern sections of Iowa and Nebraska, the latter part of April and first of May.

In Minnesota and Dakota, the usual time of hatching ranges from early in May in the southern portions to the third week in the northern extremity.

In short, the bulk of the insects hatch, in ordinary seasons, about the middle of March in latitude 35° and continue to hatch most numerous about four days later with each degree of latitude north, until along the forty-ninth parallel the same scenes are repeated that occurred in Southern Texas seven or eight weeks before.

In Montana and Manitoba, from the middle of May to the first of June.

TRANSFORMATIONS.

When first hatched the little locust is quite pale, but soon becomes mottled with gray and brown. Except in having a shorter, narrower

Fig. 10.



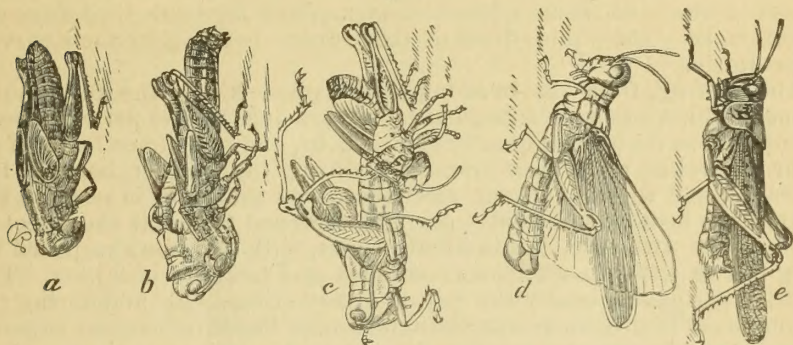
ROCKY MOUNTAIN LOCUST.—a, a, newly hatched larvæ; b, full-grown larva; c, pupa.

prothorax, sloping roof-fashion to a median ridge, and in lacking wings, the young locust scarcely differs in structure from its parent; and the perfect, winged form is gradually assumed through a series of five molts, during the first four of which the wing-pads become larger, and during the last, from the pupa (Fig. 10, c) to the perfect state, the thorax becomes flattened, the wings are acquired and the insect ceases to grow and is ready to procreate. The time required from hatching till the wings are obtained averages from six weeks to two months.

In order to illustrate the interesting process of molting we will trace an individual through the last molt—from the pupa to the winged insect—as it is the most difficult, and on account of the larger size of the animal, most easily watched. The other molts are very similar, except that the wing-pads increase but moderately in size with each. When about to acquire wings the pupa crawls up some post, weed, grass-stalk, or other object, and clutches such object securely with the hind feet, which are drawn up under the body. In doing so the favorite position is with the head downward, though this is by no means essential. Remaining motionless in this position for several hours, with antennæ drawn down over the face, and the whole aspect betokening helplessness, the thorax, especially between the wing-pads, is noticed to swell. Presently the skin along this swollen portion splits right along the middle of the head and thorax, starting by a transverse-

curved suture between the eyes, and ending at the base of the abdomen. Let us now imagine that we are watching one from the moment of this

Fig. 11.



ROCKY MOUNTAIN LOCUST.—Process of acquiring wings; *a*, pupa with skin just split on the back; *b*, the imago extruding; *c*, the imago nearly out; *d*, the imago with wings expanded; *e*, the imago with all parts perfect.

splitting, and when it presents the appearance of Fig. 11, *a*. As soon as the skin is split, the soft and white fore-body and head swell and gradually extrude more and more by a series of muscular contortions; the new head slowly emerges from the old skin, which, with its empty eyes, is worked back beneath; the new feelers and legs are being drawn from their casings, and the future wings from their sheaths. At the end of six or seven minutes our locust—no longer pupa and not yet imago—looks as in Fig. 11, *b*, the four front pupa-legs being generally detached and the insect hanging by the hooks of the hind feet, which were anchored while yet it had that command over them which it has now lost. The receding skin is transparent and loosened, especially from the extremities. In six or seven minutes more of arduous labor—of swelling and contracting—with an occasional brief respite, the antennæ and the four front legs are freed, and the full and crimped wings extricated. The soft front legs rapidly stiffen, and, holding to its support as well as may be with these, the nascent locust employs whatever muscular force it is capable of to draw out the end of the abdomen, and its long hind legs (Fig. 11, *c*). This in a few more minutes it finally does, and with gait as unsteady as that of a new-dropped colt, it turns round and clambers up the side of the shrunk, cast-off skin, and there rests while the wings expand and every part of the body hardens and gains strength—the crooked limbs straightening and the wings unfolding and expanding like the petals of some pale flower. The front wings are at first rolled longitudinally to a point, and as they expand and unroll, the hind wings, which are tucked and gathered along the veins, at first curl over them. In ten or fifteen minutes from the time of extrication these wings are fully expanded and hang down like dampened rags (Fig. 11, *d*). From this point on, the broad hind wings begin to fold up like fans beneath the narrower front ones, and in another ten minutes they have assumed the normal attitude of rest. Meanwhile the pale colors which always belong to the insect while molting have been gradually giving way to the natural tints, and at this stage our new-fledged locust presents an aspect fresh and bright (Fig. 11, *e*). If now we examine the cast-off skin we shall find every part entire with the exception of the rupture which originally took place on the back; and it would puzzle one who had not

witnessed the operation to divine how the now stiff hind shanks of the mature insect had been extricated from the bent skeleton left behind. They are in fact drawn over the bent knee-joint, so that during the process they have been bent double throughout their length. They were as supple at the time as an oil-soaked string, and for some time after extrication they show the effects of this severe bending by their curved appearance.

The molting, from the bursting of the pupa-skin to the full adjustment of the wings and straightening of the legs of the perfect insect, occupies less than three-quarters of an hour, and sometimes but half an hour. It takes place most frequently during the warmer hours of the morning, and within an hour after the wings are once in position the parts have become sufficiently dry and stiffened to enable the insect to move about with ease, and in another hour, with appetite sharpened by long fast, it joins its voracious comrades and tries its new jaws. The molting period, especially the last, is a very critical one, and during the helplessness that belongs to it the unfortunate locust falls a prey to many enemies which otherwise would not molest it, and not unfrequently to the voracity of the more active individuals of its own species.

As already stated, there are five molts exclusive of that which takes place upon leaving the egg. In the first stage—that following the egg—the wing-pads are not visible; in the second (after the first molt) they project but little beyond the meso- and meta-thorax, differ but little in size, and are directed downward, lying separately close to the body; in the third stage (after second molt) they are directed upward, the hind covering and hiding more or less the front pair, and the joints bearing them retreating more beneath the prothorax; in the fourth stage (after third molt) they are enlarged as seen in the pupa, and with the fourth molt the fifth or perfect stage is attained.

HABITS OF THE YOUNG OR UNFLEDGED LOCUSTS.

The habits of the young insects as they occur in the country south of the forty-fourth parallel are as follows: Although possessed of remarkably active powers from the moment they leave the egg, yet so long as provision suffices for them on their hatching-grounds the young remain almost stationary and create but little apprehension. As soon, however, as the supply of food in these situations is exhausted, they commence to migrate, frequently in a body a mile wide, devouring as they advance all the grass, grain, and garden-truck in their path. The migrating propensity is not developed until after the first molt. Up to that time they are content to huddle in warm places, and live, for the most part, on weeds, and especially on the common Dog-fennel or May-weed (*Maruta*) where it is present.

The young locusts display gregarious instincts from the start, and congregate in immense numbers in warm and sunny places. They thus often blacken the sides of houses or the sides of hills. They remain thus huddled together during cold, damp weather. When not traveling, and when food is abundant, or during bad, rainy weather, they are fond of congregating on fences, buildings, trees, or anything removed from the moist ground. They also prefer to get into such positions to undergo their different molts.

Their power for injury increases with their growth. At first devouring the vegetation in particular fields and patches in the vicinity of their birth-places, they gradually widen the area of their devastation, until at last they devour every green thing over extensive districts.

Whenever they have thus devastated a country they are forced to feed upon one another, and perish in immense numbers from debility and starvation. Whenever timber is accessible they collect in it, and after cleaning out the underbrush, feed upon the dead leaves and bark. A few succeed in climbing up into the rougher-barked trees, where they feed upon the foliage, and it is amusing to see with what avidity the famished individuals below scramble for any fallen leaf that the more fortunate mounted ones may chance to sever. This increase in destructiveness continues until the bulk of the locusts have undergone their larval molts and attained the pupa state. The pupa, being brighter colored, with more orange than the larva, the insects now look, as they congregate, like swarms of bees. From this time on they begin to decrease in numbers, though retaining their ravenous propensities. They die rapidly from disease and from the attacks of natural enemies, while a large number fall a prey, while in the helpless condition of molting, to the cannibalistic proclivities of their own kind. Those that acquire wings rise in the air during the warmer parts of the day, and wend their way as far as the wind will permit toward their native home in the Northwest. They mostly carry with them the germs of disease or are parasitized, and wherever they settle do comparatively little damage.

DIRECTIONS IN WHICH THE YOUNG LOCUSTS TRAVEL.

The young insects move, as a rule, during the warmer hours of the day only, feeding, if hungry, by the way, but generally marching in a given direction until toward evening. They travel in schools or armies, in no particular direction, but purely in search of food—the same school often pursuing a different course one day to that pursued the day previous. On this point the experience of 1875 is conclusive, though the bulk of the testimony as to their actions, when hatching out in States to the north and west, is to the effect that the prevailing direction taken is south or southeast, while in South Texas it is just opposite, or north. A person traveling along a road may often see them marching in one direction to the left and in the opposite direction to the right.

RATE AT WHICH THE YOUNG TRAVEL.

When about half grown they seldom move at a greater rate than three yards a minute, even when at their greatest speed over a tolerably smooth and level road, and not halting to feed. They walk three-fourths this distance and hop the rest. Two consecutive hops are seldom taken, and any individual one may be run down and fatigued by obliging it to hop ten or twelve times without a rest.

THEY REACH BUT A FEW MILES EAST OF WHERE THEY HATCH.

At the rate at which they travel, as just described, they could not extend many miles, even if they continued to travel in one direction from the time of hatching until maturity. They travel only during the hotter portions of the day, six hours on an average; and their unfledged existence terminates in from six to eight, say seven, weeks. It is very easy to calculate from these facts that if they continued in one direction from the time they hatch until they acquire wings, they could not extend thirty miles. In reality, however, they do not travel every day, and where food is abundant they scarcely travel at all. Moreover, as just shown, they do not commence traveling till after the first molt, and they do not go continually in a particularly eastern direction, but in all directions.

